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RESEARCH REPORT

Floating quantity in Shilluk

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It is well known that floating tones can associate both within a word and across a word boundary. In relation to floating quantity, however, there is extensive evidence for association within a word, but not across a word boundary. This research report presents evidence for the latter configuration in Shilluk, a West Nilotic language. Shilluk noun forms may end in floating quantity, and this quantity is realized only on following vocalic prefixes, that is, across a word boundary. The investigation includes a descriptive analysis of the phenomenon and a production study based on data from ten Shilluk speakers.*

Keywords: floating quantity, mora, phonological weight, compensatory lengthening, fusional morphology, prosody

1. INTRODUCTION. This research report is about suprasegmental units that can remain unassociated with the sequence of consonants and vowels. To illustrate the phenomenon, consider the following example from the realm of tone, drawn from McKendry 2013, who also provided the audio data. In Southeastern Nochixtlán Mixtec, an Otomanguean language, the words [nāʔā] 'hand' and [βɛ̄ʔɛ̄] 'house' have the same melodic pattern when they are pronounced in isolation. The reader can ascertain this by playing the sound files associated with 1a,b.[1] But when the same words are followed by the noun 'coyote', as in 1c,d, the melody on the initial syllable of 'coyote' depends on whether it is preceded by [nāʔā] 'hand' or [βɛ̄ʔɛ̄] 'house': the first syllable of 'coyote' is high-toned after [nāʔā] in 1c, and mid-toned after [βɛ̄ʔɛ̄] in 1d. This can be ascertained on the basis of the associated audio files.

(1) a. [nāʔā]
'hand'

b. [βɛ̄ʔɛ̄]
'house'

c. [nāʔā jájàn]
'hand of coyote'

d. [βɛ̄ʔɛ̄ jājàn]
'house of coyote'

The explanation for this is that the tone on the first syllable of 'coyote' is actually part of the lexical form of the preceding nouns. That is, 'hand' and 'house' have a tone at their right edge, which is not attached to any segmental content to begin with. Moreover, just like 'coyote', 'hand' and 'house' are not lexically specified for tone on their own first syllables, which get a mid tone by default. In sum, the underlying representations of [nāʔā] and [βɛ̄ʔɛ̄] are *naʔā*^{H} and *βɛʔɛ̄*^{M}, respectively. The high and mid 'floating tones' at the end of these words are not associated with the segmental material and are

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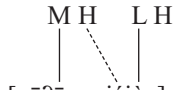
[1] Sound files are associated with almost all of the numbered examples, and these are referenced at several points throughout the paper. The audio examples are provided to clarify the phenomena, as well as for the sake of accountability. These sound files can be played at the following supplementary webpage: http://muse.jhu.edu/resolve/106.

realized only if the following context allows for their association. Example 2 presents a schematic representation of this phonological process; the association of the floating tones of *naʔā*^{H} and *βɛʔɛ̄*^{M} is represented by the dashed lines. Note that *jajàn*^{H} 'coyote' also has a floating tone, but this tone has no docking site to associate with. Finally, the mid tone on the initial syllable of *naʔā*^{H} and *βɛʔɛ̄*^{M}, that is, [nāʔā] and [βɛ̄ʔɛ̄], is inserted by default, as every syllable requires a melodic specification.

(2) a.


'hand of coyote'

b.


'house of coyote'

Floating tones have been postulated in the analysis of many languages, from a variety of language families, including Tibeto-Burman (e.g. Hyman 2010 on Kuki Thaadow), Niger-Congo (e.g. Paster 2003 on Gã), and Otomanguean (e.g. Bickmore & Broadwell 1998 on Sierra Juárez Zapotec). Floating tone also figures prominently in phonological theory, in the sense that this phenomenon has been central to the development of autosegmental theory (Goldsmith 1976, Williams 1976). Autosegmental theory accounts for the partial independence of floating tones by representing them on a separate tier, as in 2.

In this paper, the focus is on floating constituency in a different domain, namely vocalic quantity. We illustrate floating quantity using data from the Niger-Congo language Haya (Hyman & Byarushengo 1984). In this language, the morphological marking of future tense involves a lengthening of the verb prefix that marks the subject, illustrated in 3.[2] Note that first plural *tu-* in 3a lengthens to *tuu-* in 3b in the future tense, while third plural *ba-* in 3c lengthens to *baa-* in 3d.

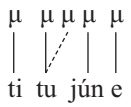
(3) a. ti-tu-jún-a
NEG-1PL-help-INFL
'we do not help'

b. ti-tu-u-jún-e
NEG-1PL-FUT-help-SBJV
'we will not help'

c. ti-ba-jún-a
NEG-3PL-help-INFL
'they do not help'

d. ti-ba-a-jún-e
NEG-3PL-FUT-help-SBJV
'they will not help'

The succinct generalization of these facts is that the future tense marker is a unit of vocalic weight, positioned between the subject marker and the lexical root of the verb. Just like the floating tones, this weight unit is not associated with any segmental content to begin with, so it associates with whatever vocalic material is available, be it /u/ as in 3b or /a/ as in 3d. We represent this weight unit as a mora (μ), following Hyman 1985 and Hayes 1989. Illustration 4 shows how this floating mora gets associated: the weight unit that marks future tense is floating to begin with, and gets associated with the vowel of the morpheme to its left.

(4)


Like floating tone, floating quantity has been invoked in the analysis of languages from a variety of language families, including Austronesian (van den Heuvel 2006 on

[2] The following abbreviations are used in the glosses: AGR: agreement, APPL: applicative, CRD: cardinal, CS: construct state, DECL: declarative, DEF: definite, DEM: demonstrative, EXSP: existential predicate, FUT: future, INDF: indefinite, IPFV: imperfective, NEG: negation, NEVP: nonevidential past, NMZ: nominalizer, NOM: nominative case, NOMP: nominal predicate, PL: plural, PR: pronoun, PRT: pertensive, PST: past, REL: relativizer, SBJV: subjunctive, SG: singular.

Biak), Niger-Congo (Hyman 2011a on Gokana), and Nilo-Saharan (Trommer 2014 on Anywa). However, there is an important difference in the crosslinguistic record between floating constituency in the realm of tone and the realm of quantity. In the case of floating quantity, the docking site of the floating constituent is to be found within the same phonological word as the floating mora. In a detailed typological and theoretical analysis of morphological quantity, Zimmermann (2017) extensively covers (i) quantity as the sole exponent of a morpheme, associated within the same phonological word, and (ii) quantity as an exponent of a morpheme alongside an affixal component, again within the same phonological word. What is lacking are cases where floating quantity is dependent for its realization on a docking site across a word boundary. This contrasts with the situation with regard to floating tones, where both docking within the same word (e.g. Paster 2003 on Gã) and docking across a word boundary (e.g. McKendry 2013 on Southeastern Nochixtlán Mixtec, discussed above) are widely attested. This difference between tone and quantity with respect to floating constituency relates to a more general pattern, articulated by Hyman (2011b:214, 2018:699): 'Tone can do everything segments and non-tonal prosodies can do, but segments and non-tonal prosodies cannot do everything tone can do'.

The present paper presents evidence that floating quantity actually can associate across a word boundary, just as floating tone can. We focus on Shilluk, a Nilo-Saharan language that is spoken primarily in South Sudan. A first illustration of the phenomenon is presented in 5.[3] When the words [kùl] 'warthog' and [tùl] 'foreheads' appear in utterance-final position, there is no difference in syllable structure or quantity. This is shown in 5a,b and further supported by the associated sound files. But there is a difference when they are followed by the verb *á-lîɪɪṯ-à* as in 5c,d: the prefix *á-*, which marks past tense, has considerably greater duration following [tùl] than following [kùl]. This is represented in the phonetic form [ǎalîɪɪǹ̪à] in 5d. Also, the tone pattern of the *á-* is rising in 5d, as the specification for low tone of the preceding noun carries through to the beginning of the following prefix vowel.

(5) a. [gîn bǎa kùl]
gîn bǎa kùl
something:DEM NOMP warthog
'This thing is a warthog.'

b. [gîk bǎa tùl]
gîk bǎa tùlᵘ
something.PL:DEM NOMP forehead:PL
'These things are foreheads.'

[3] Our transcription of Shilluk speech largely follows the IPA standard, except for vowel length and tone. In relation to vowel length, Shilluk has a ternary vowel length contrast (Remijsen, Ayoker, & Jørgensen 2019), with short, long, and overlong vowels. We transcribe a long vowel using two identical vowel symbols in sequence (e.g. *míʌn* 'women'), and an overlong vowel using three identical vowel symbols (e.g. *càaam* 'eat:2SG'). In relation to tone, the complexity of the inventory brings us to use some idiosyncratic conventions. The Shilluk tone inventory includes nine tone categories that are contrastive on stem syllables as a result of lexical and morphological specification. They are low (cv̀c), mid (cv̄c), high (cv́c), low fall (cv̂c), high fall (cv̋c), high fall to mid (cv̋̄c), late fall (cv́̀c), low rise (cv̌c), and high rise (cv̏̌c). Various tone categories are transcribed using multiple tonal diacritics, either on a vowel character or distributed over vowel and coda. This is an ad hoc solution to the need to distinguish nine tone categories: all nine of the tones have the syllable as their domain of association.

c. [kùl álîɪɪɖà]
kùl á-lîɪɪṭ-à
warthog PST-look-1SG
'I looked at the warthog.'

d. [tùl ăalîɪɪɖà]
tùlᵘ á-lîɪɪṭ-à
forehead:PL PST-look-1SG
'I looked at the foreheads.'

As seen from the phonological transcription, we analyze this phenomenon in terms of floating quantity, postulating a mora at the right edge of *tùl*ᵘ 'foreheads'. Crucially, this weight unit is dependent for its realization on a docking site across a word boundary. Illustration 6a presents a schema of the association of this floating mora across the word boundary. For the sake of comparison, 6b presents the schema for the association of floating tone in Southeastern Nochixtlán Mixtec across the same prosodic domain boundary, repeated from 2a above. In 6a and 6b alike, we have represented the association of the floating constituent—a weight unit in 6a, a tone in 6b—using a dashed line.

(6) a. μ μ μ μμμ μ b. M H L H
[tùl ăa-lîɪɪɖ-à] [nāʔā jájàn]

Aside from Shilluk (Remijsen & Ayoker 2019), floating quantity has also recently been reported for Nuer (Reid 2019), a closely related language. However, for neither of these languages has this phenomenon been investigated in detail. The goal of this paper is to present a descriptive analysis of this phenomenon in Shilluk, supported by quantitative evidence.

The paper is structured as follows. The remainder of this introduction provides background information on the morphological paradigms of nouns (§1.1) and on the composition of the phonological word (§1.2). Following this, §2 offers a descriptive analysis of the role of the floating mora in Shilluk morphophonology. We then report on an acoustic study that corroborates this descriptive analysis (§3). In §4 we consider alternative analyses and the diachronic development of the phenomenon.

1.1. BACKGROUND ON THE INFLECTIONAL PARADIGM OF SHILLUK NOUNS. To the best of our knowledge, the floating weight unit appears only in nouns, and never in verbs or in adjectives. To explain where, it is necessary to introduce the inflectional paradigm of Shilluk nouns. This analysis builds on the description of the morphophonology of Shilluk nouns in Remijsen & Ayoker 2019. While the singular and plural forms of Shilluk nouns are in most cases formally related, this relation is not predictable (Gilley 1992, Remijsen, Miller-Naudé, & Gilley 2015, Xu 2017). Hence, we treat the inflectional paradigms of singular and plural nouns independently. The inflectional paradigm of singular nouns distinguishes up to five forms:

- base form
- pertensive with singular possessor
- pertensive with plural possessor
- construct state
- proximal demonstrative

For plural nouns, the paradigm distinguishes up to four forms—one fewer than the singular form, as there is only one pertensive form, irrespective of the number of the possessor. These paradigms are illustrated in Table 1, which presents two singular nouns and two plural nouns.

	SINGULAR		PLURAL	
	SUFFIXLESS	SUFFIXED	SUFFIXLESS	SUFFIXED
	‘king’	‘thorn’	‘thorns’	‘kings’
BASE	rɑ̄ʈ̪	kʊ́ʊʊ̄ʈ̪-ɔ̄	kʊ́ʊʊʈ̪ᵘ	rʌ́ʌn̄-ī
PERTENSIVE (SG)	rɑ̄ʌʌʈ̪ᵘ	kʊ́ʊn̄-ī	kʊ́ʊʈ̪-í	rʌ́ʌn̪-í
PERTENSIVE (PL)	rɑ̆ʌʌʈ̪	kʊ́ʊn̪-í		
CONSTRUCT STATE	rɑ̄ʌʌn̪	kʊ́ʊn̄-ī	kʊ́ʊʈ̪-ī	rʌ́ʌn̄-ī
DEMONSTRATIVE	rɑ̄ʌʌǹ̪ᵘ	kʊ́ʊn̪-ì	kʊ́ʊʈ̪-ì	rʌ́ʌn̪-ì

TABLE 1. Illustration of the inflectional paradigms of singular and plural nouns, both suffixless and suffixed.

As seen from Table 1, both singular and plural nouns can be either suffixless or suffixed in the base form. Moreover, if a singular base form is suffixless, as in the case of *rɑ̄ʈ̪* ‘king’, then all of its inflected forms are suffixless as well. By implication, the inflections of a suffixless noun are marked solely through a combination of stem-internal markers, especially tone, vowel length, nasalization, and the floating mora. In contrast, if a singular base form is suffixed, as in the case of *kʊ́ʊʊʈ̪-ɔ̄* ‘thorn’,[4] then so are its inflected forms.[5] In relation to plural nouns, here as well there are both suffixless and suffixed base forms, but the inflected forms are invariably suffixed. In general, when an inflection involves suffixation, it is typically not exclusively suffixal. Instead, suffixation functions as part of a package of morphological exponence, along with specifications of vowel length, tone, and coda nasalization.

In the remainder of this subsection we briefly introduce the function of each of the forms within the inflectional paradigm. To begin with, the base form is used when a noun is used without a modifier, as in 7a. It is also used when the noun is modified using the indefinite modification marker, which is *mɛ́* when the head noun is singular, as in 7b, and *mɔ́* if it is plural.

(7) a. lwáak á-lîɪɪʈ̪-à
barn PST-look-1SG
‘I looked at the barn.’

b. lwáak mɛ́ dwɔ̋ɔŋ
barn INDF.REL.SG big
‘a big barn’

If a noun is modified by a possessor, it appears in the pertensive.[6] This is illustrated in 8, which shows the pertensive inflections of the noun *lwáak* ‘barn’. It is important to note here that the morphological marking is found on the possessed term of the possessive noun phrase. This is different from genitive, in which the possessor term is morphologically marked. In the case of singular nouns, there are in fact two pertensive forms: one that is used if the modifying possessor is singular, and one that is used when the possessor is plural. This distinction is illustrated in 8a vs. 8b, respectively. Note that the pertensive with singular possessor is marked by a high fall to mid tone (*lwɑ́ɑɑk̄ᵘ*), and the pertensive with plural possessor by a high tone (*lwáaak*). The examples in 8 make clear that the difference in specification for tone on the possessed term cannot be attributed to the tonal context, because the following possessor noun is high-toned in both cases. Plural nouns modified by a possessor present only one pertensive form: here the number of the possessor is not a factor.

(8) a. lwɑ́ɑɑk̄ᵘ twɔ̋ɔŋ
barn:PRT.SG Twong
‘Twong’s barn’

b. lwáaak mʌ́ʌn
barn:PRT.PL women
‘the women’s barn’

[4] In the nominal system, the suffix *-ɔ* is found only in singular base forms.
[5] A set of exceptions to this generalization is introduced in §2.4.
[6] This term comes from Dixon (2010:268).

The final two forms are the construct state and the proximal demonstrative. A noun appears in the construct state form when accompanied by a modifier other than the ones mentioned so far. That is, the construct state is used when the noun is modified by an adjective, a definiteness marker, or a relative clause, among other situations. This form is illustrated in 9a. Finally, the proximal demonstrative form is expressed as an inflection when the demonstrative and its head are not separated by any other modifiers, as in 9b.

(9) a. lwáaaŋ̄ à dwɔ́ɔŋ
barn:CS DEF.REL big
'the big barn'

b. lwáaaŋ̀ᵘ
barn:DEM
'this barn'

Within this inflectional paradigm, the floating mora is to be found in four different forms, all of which are suffixless:

- the base form of the majority of suffixless plural nouns
- the proximal demonstrative of suffixless singular nouns
- the pertensive with singular possessor of suffixless singular nouns
- the base form of an exceptional set of singular nouns (twenty-three nouns)

In §2, we describe the role of floating quantity in each of these four inflections. Before that we need to discuss the shape of Shilluk words, because this shape determines whether floating quantity can dock.

1.2. BACKGROUND ON THE PHONOTACTIC STRUCTURE OF SHILLUK WORDS. Floating quantity docks across a word boundary in a specific context. In order to make reference to this context in the descriptive analysis (§2), we now summarize the phonotactic structure of Shilluk words. The great majority of Shilluk content words present a monosyllabic stem with the following phonotactic structure: C(w/j)V(V)(V)C. As seen from this template, the stem consists of a single closed syllable, and consonantal complexity is restricted to the onset, where a semivowel can follow another consonant. Moreover, the stem vowel can be short (V), long (VV), or overlong (VVV) (Remijsen, Ayoker, & Jørgensen 2019).

The predominance of this template is evidenced by the fact that, of 592 transitive verbs in our data set, all are monosyllabic, and only two are onsetless. Examples of nouns illustrating this stem shape are presented in 10.

(10) *mûn-ɔ̀* 'neck-SG', *kwʌ̄n* 'porridge', *djêk* 'goats', *jāaṭ* 'tree', *ṭɔ́ɔl* 'rope', *ɟáaak̄-ɔ̄* 'chief-SG', *ŋùuur* 'lion', *mwɔ̆̄ɔɔlᵘ* 'morning'

This monosyllabic stem may be preceded by a prefix and followed by a suffix. Of these, only the prefix is relevant to the phenomenon of floating quantity. The range of prefixes is limited, and only two of them are found with frequency in the lexicon, both of them vocalic: *a-* and *ʊ-* (Remijsen & Ayoker 2019). There are hundreds of nouns that are formed with each of these. In most cases, these initial vowels are derivational prefixes, expressing a variety of meanings. For example, *á-* derives a cardinal numeral from an ordinal numeral in the case of *á-dʌ̀k* (CRD-third) 'three', and *ɔ̀-* derives a result noun from a transitive verb in the case of *ɔ̀-pɛ̀ɛt* (NMZ-cut.to.dry) 'dried fish'. In verbs, the same two prefixes *a-* and *ʊ-*, with various specifications for tone, have a high functional load in the inflectional paradigm, marking levels of tense-aspect-modality in a regular and productive manner (Remijsen & Ayoker 2018). For example, the verb *càm* 'eat' has the past-tense form *á-càm*, and the future-tense form *ʊ́-cʌ́m̄*. Finally, there are also words with the initial vowels *a-* and *ʊ-* that follow the same phonotactic template, but are not obviously related to a monosyllabic word without these vowels. Examples include *ʊ́gǐik* 'buffalo', *áŋwʌ̄ʌk* 'oryx', and *áwʌ̀ʌ* 'yesterday'. Here the initial vowel is not a prefix in the morphological sense, at least synchronically.

In relation to the phenomenon of floating quantity, these polysyllabic words that begin with the initial vowels *a-* and *ʊ-* are particularly important, because these initial vowels represent the environment in which floating quantity can dock. Moreover, it is irrelevant whether the initial vowel is inflectional, as in the case of a verb like *ʊ́-cā́m̄* 'FUT-eat', derivational, as in the case of a nominalization such as *ʊ̀-pɛ̀ɛt* (NMZ-cut.to.dry) 'dried fish', or part of the root, as in the case of *ʊ́gǐik* 'buffalo'. For ease of reference, we refer to all of these instances of word-initial *a-*/*ʊ-* in polysyllabic words as vocalic prefixes.

2. DESCRIPTIVE ANALYSIS OF FLOATING QUANTITY IN SHILLUK.

2.1. FLOATING QUANTITY IN PLURAL BASE FORMS. The floating mora is found only in suffixless nouns, which, in the paradigm of plural nouns, are limited to the base form (see Table 1). And the floating mora is indeed found there—not in all suffixless plurals, but in the majority of them.

This is illustrated in 11, which presents a suffixless plural that displays floating quantity—*tɔ̀kᵘ* 'edges'—and a suffixless plural that does not—*d̪ɔ̀k* 'cows'. In 11a,b, both are followed by the prefix *á-*, which derives cardinal numbers from ordinal numbers. Playing the sound files, the reader can ascertain that this prefix vowel sounds longer following *tɔ̀kᵘ* 'edges' in 11a than following *d̪ɔ̀k* 'cows' in 11b. In addition, the tone of the *á-* is lowered following *tɔ̀kᵘ*, as the quantity that spreads rightward carries with it the low specification for tone on *tɔ̀kᵘ*. In contrast, when these nouns are followed by *mɔ́*, the plural allomorph of the indefinite relativizer, as in 11c,d, then there is no difference in quantity or tone. The same is true if they appear in utterance-final position, as in 11e,f: then as well, the floating quantity is not realized.

(11) a. [tɔ̀k ǎaŋwɛ̀ɛn]
tɔ̀kᵘ á-ŋwɛ̀ɛn
edge:PL CRD-fourth
'four edges'

b. [d̪ɔ̀k áŋwɛ̀ɛn]
d̪ɔ̀k á-ŋwɛ̀ɛn
cow.PL CRD-fourth
'four cows'

c. [tɔ̀k mɔ́ dɔ̀ɔŋɔ̀]
tɔ̀kᵘ mɔ́ dɔ̀ɔŋ-ɔ̀
edge:PL INDF.REL.PL big-PL
'big edges'

d. [d̪ɔ̀k mɔ́ dɔ̀ɔŋɔ̀]
d̪ɔ̀k mɔ́ dɔ̀ɔŋ-ɔ̀
cow.PL INDF.REL.PL big-PL
'big cows'

e. [dâa tɔ̀k]
dâa tɔ̀kᵘ
EXSP:F edge:PL
'There are edges.'

f. [dâa d̪ɔ̀k]
dâa d̪ɔ̀k
EXSP:F cow.PL
'There are cows.'

As noted above, not just the cardinal marker, but any vocalic prefix represents a suitable docking site. This is shown in 12, where the following vocalic prefix is the imperfective marker *ʊ̀-* in 12a,b and the nonevidential marker *ʊ́-* in 12c,d. The associated audio examples enable the reader to ascertain that both of these prefixes have greater duration following *tɔ̀kᵘ* in 12a,c than following *d̪ɔ̀k* in 12b,d.

(12) a. [tɔ̀k ʊ̀ʊlîɪɪɖ̪ɔ̀]
tɔ̀kᵘ ʊ̀-lîɪɪt̪-ɔ̀
edge:PL IPFV-look-IPFV
'Somebody is looking at the edges.'

b. [d̪ɔ̀k ʊ̀lîɪɪɖ̪ɔ̀]
d̪ɔ̀k ʊ̀-lîɪɪt̪-ɔ̀
cow.PL IPFV-look-IPFV
'Somebody is looking at the cows.'

c. [tɔ̀k ʊ̈ʊlîɪɪɖ̈ɔ̀]
tɔ̀kᵘ ʊ̈-lîɪɪṯ̈-ɔ̀
edge:PL NEVP-look-NEVP
'Somebody apparently looked at the edges.'

d. [ɖ̈ɔ̀k ʊ́lîɪɪɖ̈ɔ̀]
ɖ̈ɔ̀k ʊ́-lîɪɪṯ̈-ɔ̀
cow.PL NEVP-look-NEVP
'Somebody apparently looked at the cows.'

The vocalic prefixes *a-*, *ʊ-* are found on nouns and verbs alike in Shilluk, with a variety of functions, and these vowels are also found at the left edge of words that are monomorphemic in a synchronic sense. As noted in §1.2, for the docking of the floating weight unit it does not make a difference whether these initial vowels represent a separate morpheme or are part of the lexical root instead. For example, the initial vowels of the monomorphemic noun *ʊ́gɪ̌ik* 'buffalo' and the adverb *áwʌ̀ʌ* 'yesterday' can accommodate the floating mora.

In contrast, if the following word begins with a consonant, then the floating quantity cannot dock. This is illustrated in 11c,d above, and further in 13a,b: there is no salient difference in the duration of the onset or the stem vowel of the following word as a function of the presence (as in 13a) or absence (as in 13b) of floating quantity in the preceding word.[7]

(13) a. [tɔ̀k lîɪɪɖ̈ èn]
tɔ̂kᵘ lîɪɪṯ̈ ê̂n
edge:PL look:NEVP PR.3SG.NOM
'S/he apparently looked at the edges.'

b. [ɖ̈ɔ̀k lîɪɪɖ̈ èn]
ɖ̈ɔ̀k lîɪɪṯ̈ ê̂n
cow.PL look:NEVP PR.3SG.NOM
'S/he apparently looked at the cows.'

Another conceivable scenario is for the following word to begin with a vowel other than *a-*, *ʊ-*. This situation is very rare, because, aside from words beginning with these vowels, content words are predominantly monosyllabic and consonant-initial, as noted in §1.1. For example, the only two vowel-initial transitive verb roots of the 592 in our data set are {òr} 'send' and {ʌ̀l} 'turn over soil using hoe'. Here as well, there is no salient difference in the duration of the stem vowel of the verb as a function of the presence (as in 14a) vs. the absence (as in 14b) of floating quantity in the preceding word. The fact that stem vowels do not lengthen as a function of floating quantity originating in a preceding word is perhaps not surprising, since in verbs, nouns, and adjectives alike, the duration of the stem vowel already has a high functional load, in that it expresses both lexical and morphological contrast (Remijsen, Ayoker, & Jørgensen 2019).

(14) a. [tɔ̀k òr èn]
tɔ̂kᵘ òr ê̂n
edge:PL send:NEVP PR.3SG.NOM
'S/he apparently sent the edges.'

[7] This blocking of the association of a vocalic mora across a word boundary by a consonant in Shilluk runs parallel to such blocking in a word-internal context, that is, between a prefix and a base, as reported for Bukusu (Mutonyi 2000, Zimmermann 2017:183–84).

b. [ḍòk òr èn]
ḍòk òr ên
cow.PL send:NEVP PR.3SG.NOM
'S/he apparently sent the cows.'

We noted at the beginning of this section that not all suffixless plurals have the floating weight unit in the base form. On the basis of a data set of 324 suffixless plural base forms, we estimate that between 75 and 80 percent of them have floating quantity. In other words, most suffixless plurals do have the floating mora in the base form. Some additional examples are presented in 15. They show that the presence or absence of floating quantity in suffixless plural base forms is not predictable based on the vowel length of the stem syllable.

(15) a. [tɔ̂ŋ ăadʌ̀k]
tɔ̂ŋ$^{\mu}$ á-dʌ̀k
spear:PL CRD-third
'three spears'

b. [wɔ̀ɔŋ ăadʌ̀k]
wɔ̀ɔŋ$^{\mu}$ á-dʌ̀k
grandmother:PL CRD-third
'three grandmothers'

c. [pàaal ăadʌ̀k]
pàaal$^{\mu}$ á-dʌ̀k
knife:PL CRD-third
'three knives'

Within the above-mentioned set of 324 suffixless plural nouns, seventy-two do not have the floating mora. Sixty of these have either a high or a mid tone. These forms are illustrated in 16. This pattern is consistent: that is, none of the suffixless plurals in the set of 324 nouns that carry a high tone or a mid tone have the floating weight unit. Therefore we hypothesize that this generalization holds for the population of high- and mid-toned suffixless plural nouns as a whole. It is noteworthy that none of these sixty high- or mid-toned nouns have an overlong vowel. And in turn, there are no suffixless plurals with an overlong vowel that carry a high or a mid tone.

(16) a. [rícádʌ̀k]
rícá-dʌ̀k
fish.PL CRD-third
'three fish'

b. [lɛ̄gádʌ̀k]
lɛ̄ká-dʌ̀k
tooth.PL CRD-third
'three teeth'

c. [mʌ́ʌnádʌ̀k]
mʌ́ʌná-dʌ̀k
woman.PL CRD-third
'three women'

d. [dōoradʌ̀k]
dōorá-dʌ̀k
wall.PL CRD-third
'three walls'

Aside from the high/mid-toned suffixless plurals, we know of twelve other suffixless plurals that lack the floating weight unit: *cwɔ̂w* 'men', *cjʌ̂ʌŋ* 'days', *ḍòk* 'cows', *djêk* 'goats/sheep', *pʌ̂t* 'spoons', *ɟɪ́ɪ* 'people', *câak* 'milk', *pʌ̂ʌt* 'bark (pl.)', *pîi* 'water', *cjɛ̂ṭ* 'excrement', *rûun* 'years', and *ɟɔ̂k* 'men'.[8] While there are probably some more such

[8] For the mass nouns within this set, their plural number can be ascertained unambiguously on the basis of number agreement within the noun phrase.

words, it is clear that the lack of the floating mora is rare among suffixless plurals that do not have a high or mid tone.

Regarding which suffixless plurals have the floating mora and which do not, there are indications that the floating mora represents morphological marking for number in plural base forms. First, all suffixless plurals that have an overlong stem vowel have the floating mora. This is meaningful, because overlength in West Nilotic languages is the diachronic outcome of a lost suffix, reinterpreted as part of the stem through compensatory lengthening (Andersen 1990). Second, a long stem vowel is in turn characteristic of the lack of morphological marking, and almost all of these lack the floating mora. The only suffixless plural nouns with a long vowel that do display the floating mora are *wɔ̀ɔŋ*$^{\mu}$ 'grandmothers' and *ɔ̂ɔt*$^{\mu}$ 'houses'. Finally, several of the twelve other suffixless plurals noted above that lack floating quantity (*cwɔ̂w* 'men', *ḍòk* 'cows', *ɟìɪ* 'people') are suppletive relative to the corresponding singular, which is in line with the interpretation that they are morphologically unmarked.

There is further evidence in support of the interpretation that floating quantity in suffixless plural base forms is an instance of morphological marking. Gilley (1992) argues that singular-plural pairs in Shilluk can be morphologically marked (i) in the plural (plural marking), (ii) in the singular (singulative marking), or (iii) in both singular and plural (replacement marking). Dimmendaal (2000) discusses this 'tripartite' system of number marking in relation to the Nilo-Saharan language as a whole. Potentially problematic for this analysis are singular-plural pairs like those in 17. Aside from the floating mora hypothesized in the current descriptive analysis, there is no evidence of morphological marking in either the singular or the plural. With respect to 17a–c, both low and low fall tones are found in uninflected roots. As for vowel length, both a change from short to long and a change from long to short are attested in morphological paradigms, so the vowel length alternation offers no indication as to which form is morphologically marked. The same goes for the nouns in 17d–f: aside from the floating mora, they differ solely in terms of tone. Both high and low fall are found in combination with a short stem vowel in singular and in plural nouns.

(17) a. lûum – lùm$^{\mu}$ 'grass:SG – PL' b. dɔ́k – dɔ̂k$^{\mu}$ 'mouth:SG – PL'
c. tûuŋ – tùŋ$^{\mu}$ 'horn:SG – PL' d. líŋ – lîŋ$^{\mu}$ 'war:SG – PL'
e. pîɪl – pɛ̀l$^{\mu}$ 'grindstone:SG – PL' f. cúl – cûl$^{\mu}$ 'penis:SG – PL'

For both sets of nouns, if we do not recognize the floating weight unit, then we are left with singular-plural pairs that are obviously not suppletive, yet neither singular nor plural is morphologically marked, a configuration that has so far been hypothesized not to exist, either in Shilluk (Gilley 1992) or in the Nilo-Saharan language family at large (Dimmendaal 2000). In contrast, if we recognize the floating mora and interpret it as an instance of morphological marking, then Shilluk is not anomalous within the Nilo-Saharan language family: nominal pairs for number such as those in 17 can be interpreted as instances of plural marking.

2.2. FLOATING QUANTITY IN THE DEMONSTRATIVE OF SUFFIXLESS SINGULAR NOUNS. Suffixless singular nouns consistently have the floating mora in the proximal demonstrative inflection. Just as with plural nouns, any following vocalic prefix serves as a docking site. This is illustrated in 18, which shows the base form of the suffixless singular noun *kùl* 'warthog', and the corresponding proximal demonstrative form *kùl*$^{\mu}$. In the paradigm of this noun, the floating mora is the only morphophonological marker that distinguishes the base form from the proximal demonstrative. Illustration 18 presents these two noun forms each followed by three different vocalic prefixes: the past-

tense marker *á-* in 18a,b, the nonevidential past marker *ǿ-* in 18c,d, and the imperfective marker *ǿ̀-* in 18e,f. Importantly, each of these prefixes displays increased duration following the proximal demonstrative form *kùlᵘ* in 18b,d,f, but not after the base form *kùl* in 18a,c,e.

(18) a. [kùl álîɪɪɲà]
kùl á-lîɪɪt̪-à
warthog PST-look-1SG
'I looked at the warthog.'

b. [kùl ăalîɪɪɲà]
kùlᵘ á-lîɪɪt̪-à
warthog:DEM PST-look-1SG
'I looked at this warthog.'

c. [kùl ǿlîɪɪɲɔ̀]
kùl ǿ-lîɪɪt̪-ɔ̀
warthog NEVP-look-NEVP
'Somebody apparently looked at the warthog.'

d. [kùl ǿʊlîɪɪɲɔ̀]
kùlᵘ ǿ-lîɪɪt̪-ɔ̀
warthog:DEM NEVP-look-NEVP
'Somebody apparently looked at this warthog.'

e. [kùl ǿ̀lîɪɪɲɔ̀]
kùl ǿ̀-lîɪɪt̪-ɔ̀
warthog IPFV-look-IPFV
'Somebody is looking at the warthog.'

f. [kùl ǿ̀ʊlîɪɪɲɔ̀]
kùlᵘ ǿ̀-lîɪɪt̪-ɔ̀
warthog:DEM IPFV-look-IPFV
'Somebody is looking at this warthog.'

2.3. FLOATING QUANTITY IN THE PERTENSIVE WITH A SINGULAR POSSESSOR OF SUFFIXLESS SINGULAR NOUNS. In the inflectional paradigm of suffixless singular nouns, the floating weight unit is also consistently part of the inflectional marking of the pertensive with a singular possessor. For this inflection, however, the docking site is more restricted than in the plural and in the proximal demonstrative. That is, a floating mora marking pertensive with singular possessor conditions lengthening of a following vocalic prefix only if this prefix has the vowel quality /a/ and carries a high tone.

We first demonstrate that the vowel quality of the docking site has to be /a/, and then that it has to carry a high tone. The first conditioning factor is illustrated in 19. All of the noun phrases in these examples are headed by the possessed term *gɔ́l̄ᵘ*, which is a pertensive with singular possessor of a suffixless singular noun and therefore has floating quantity. This illustration presents two minimal sets in the possessor term, *á-tɔ̀r*/*ǿ-tɔ̀r* in 19a,b and *á-láam*/*ǿláam* in 19c,d, each differing only in the quality of the initial vowel of the possessor. Floating quantity triggers lengthening in *á-tɔ̀r* 'Ator' (woman's name), but not *ǿ-tɔ̀r* 'Otor' (man's name).[9] And likewise, there is increased

[9] There is a sandhi process in the examples in which the floating quantity does not condition lengthening, as in 19b,d. A high fall to mid on a head noun inflected for pertensive with singular possessor, as in *gɔ́l̄* 'compound:PRT.SG', changes to a level high tone when the following possessor carries the prefix *ǿ-*. Sandhi across a word boundary is very rare in Shilluk. This sandhi process is not triggered when the following possessor carries a high tone but there is no prefix *ǿ-*: *gɔ́l̄ᵘ twɔ́ɔŋ* [gɔ́l̄ twɔ́ɔŋ] 'Twong's compound'.

duration in the initial vowel of *á-láam* ‘Alam’ (woman’s name), but not in the initial vowel of *ǿláam* ‘fig’.[10]

(19) a. [gɔ́l̄ āatɔ̀r]
gɔ́l̄$^{\mu}$ á-tɔ̀r
compound:PRT.SG Ator (NMZ-forest)
‘the compound of Ator’

b. [gɔ́l ǿtɔ̀r]
gɔ́l̄$^{\mu}$ ǿ-tɔ̀r
compound:PRT.SG Otor (NMZ-forest)
‘the compound of Otor’

c. [gɔ́l̄ ǎaláam]
gɔ́l̄$^{\mu}$ á-láam
compound:PRT.SG Alam (NMZ-prayer)
‘the compound of Alam’

d. [gɔ́l ǿláam]
gɔ́l̄$^{\mu}$ ǿláam
compound:PRT.SG fig
‘the compound of the fig tree’

Aside from vowel quality, the docking of floating quantity in the pertensive with singular possessor is also contingent on the specification for tone of the following noun: the floating mora conditions lengthening of a following vocalic prefix /a/ only if this prefix is high-toned. This is shown in 20: the initial vowels of *á-tɔ̀r* in 20a and *á-bác* in 20b display increased duration, indicating that the floating weight unit has associated across the word boundary here, but the initial vowel of *à-cʌ̀k* in 20c does not. The key difference is the specification for tone of the prefix vowel: high-toned in 20a,b and low-toned in 20c.

(20) a. [gɔ́l̄ āatɔ̀r]
gɔ́l̄$^{\mu}$ á-tɔ̀r
compound:PRT.SG Ator (NMZ-forest)
‘the compound of Ator’

b. [gɔ́l̄ ǎabác]
gɔ́l̄$^{\mu}$ á-bác
compound:PRT.SG Abac (NMZ-amniotic.sac)
‘the compound of Abac’

c. [gɔ́l̄ àcʌ̀k]
gɔ́l̄$^{\mu}$ à-cʌ̀k
compound:PRT.SG NMZ-compose
‘the compound of the composer’

2.4. Floating quantity in singular base forms. The fourth and final set of nouns that present the floating weight unit are an exceptional group of singular base forms. Just as when floating quantity marks plural or proximal demonstrative, any following vocalic prefix serves as a docking site. Three examples are presented in 21a,b,c, where these nouns are followed by the cardinal marker *á-*. As a vocalic prefix, this marker is a docking site for the floating weight unit. The singular base forms in 21d,e,f do not have a floating mora; these examples are included for the sake of comparison. The associated

[10] We assume that it is irrelevant here that the initial vowel of *ǿláam* ‘fig’ is not a prefix (see the discussion in §§1.2, 2.1).

audio examples illustrate that the prefix *á-* that follows the target words sounds saliently longer in 21a,b,c than in 21d,e,f.

(21) a. [pǔk áakjèl]
pǔkᵘ á-kjèl
storage.pot CRD-first
'one storage pot'

b. [kǐt áakjèl]
kǐtᵘ á-kjèl
mountain CRD-first
'one mountain'

c. [kʌ̌ʌʌk áakjèl]
kʌ̌ʌʌkᵘ á-kjèl
harpoon CRD-first
'one harpoon'

d. [bàt ákjèl]
bàt á-kjèl
arm CRD-first
'one arm'

e. [wāŋ ákjèl]
wāŋ á-kjèl
eye CRD-first
'one eye'

f. [ʊ́gǐik ákjèl]
ʊ́gǐik á-kjèl
buffalo CRD-first
'one buffalo'

We know of a total of twenty-three singular nouns that have the floating mora in the base form. Five of these have a short vowel: *bě̱tᵘ* 'fishing spear', *kɔ̌cᵘ* 'hoe', *kǐtᵘ* 'mountain', *pǔkᵘ* 'pot for storage', and *ʊ́kǐtᵘ* 'dough'. The remaining eighteen have an overlong vowel: *cěeewᵘ* 'porcupine', *cjěeenᵘ* 'curse', *dǐiimᵘ* 'sieve', *dǔuulᵘ* 'door bar', *gǔuu̱tᵘ* 'thick short stick', *gʌ́ʌʌcᵘ* 'baobab', *jǒooᵘ* 'road', *kǐiilᵘ* 'crutch', *kʌ́ʌʌkᵘ* 'harpoon', *kwɛ̌ɛɛrᵘ* 'hoe for weeding', *lěeewᵘ* 'house lizard', *lǐiipᵘ* 'awl (for taking out thorns)', *ŋǒoomᵘ* 'awl (for piercing)', *t̪ʌ́ʌʌᵘ* 'desert date (tree)', *t̪ǎaakᵘ* 'hat', *ɲǎaawᵘ* 'domestic cat', *mwɔ̃̌ɔɔlᵘ* 'morning', and *ápwâaakᵘ* 'Anywa'. Apart from the last one, *ápwâaakᵘ* 'Anywa (ethnic group)', they all have a rising contour tone in the base form. In all but two cases, it is the low rise; *ɲǎaawᵘ* 'domestic cat' and *mwɔ̃̌ɔɔlᵘ* 'morning' are the only ones that have the high rise. However, while most singular nouns that have a rising melody on the stem syllable have floating quantity, this pattern is not consistent: *gwǎŋ* 'wild cat' and *ʊ́gǐik* 'buffalo' both have low rise, but they do not have floating quantity.

The explanation for the presence of floating quantity in the above-mentioned twenty-three nouns can be inferred from the inflectional paradigm. As noted in relation to Table 1, most singular nouns are either suffixless or suffixed. If they are suffixless in the base, then they are equally suffixless throughout the inflected forms, and if they are suffixed in the base, then the inflected forms are suffixed as well. The twenty-three nouns at issue here constitute an exception to this generalization: while they are suffixless in the base form, they are suffixed in the inflected forms. This is illustrated in Table 2. Note that *kǐtᵘ*, *ŋǒoomᵘ*, and *mwɔ̃̌ɔɔlᵘ* have suffixes in the inflected forms, just as the regular suffixed noun *pʌ̀ʌʌt-ɔ́* does. But unlike the latter, their base is suffixless.

	SUFFIXLESS BASE, SUFFIXED INFL.			SUFFIXLESS	SUFFIXED
	'mountain'	'awl'	'morning'	'wild cat'	'bark'
BASE	kǐtᵘ	ŋǒoomᵘ	mwɔ̃̌ɔɔlᵘ	gwǎŋ	pʌ̀ʌʌt-ɔ́
PERTENSIVE (SG)	kìt-ì	ŋòom-ì	mwɔ̃ɔl-ī	gwàaaŋᵘ	pʌ̀ʌt-ì
PERTENSIVE (PL)	kìt-í	ŋòom-í	mwɔ̃ɔl-í	gwǎaaŋ	pʌ̀ʌt-í
CONSTRUCT STATE	kìn-ì	ŋòom-ì	mwɔ̃ɔl-ī	gwàaaŋ	pʌ̀ʌn-ì
DEMONSTRATIVE	kìn-ì	ŋòom-ì	mwɔ̃ɔl-ì	gwàaaŋᵘ	pʌ̀ʌn-ì

TABLE 2. The inflectional paradigms of three nouns that display a suffixless base form but suffixed inflections. Regular suffixed and suffixless nouns are presented alongside.

The pattern of vowel length alternation in this exceptional set also follows that of suffixed paradigms. In both cases, if there is a length alternation in the stem vowel within the inflectional paradigm, then the vowel is overlong in the base form, and either short

or long in the inflected forms (cf. Remijsen, Ayoker, & Jørgensen 2019). This can be seen from comparing the vowel length alternation in the paradigm of *ŋǒoom*$^{\mu}$ 'awl' with that in the paradigm of *pʌʌt-ɔ́* 'bark'. In regular suffixless nouns, in contrast, the pattern of length alternation within the paradigm is the reverse: there the vowel is short or long in base forms, and overlong in inflected forms. This is illustrated by *gwǎŋ* 'wild cat' in Table 2.

We hypothesize that the twenty-three nouns that are suffixless in the base but suffixed in the inflected forms used to have a suffix *-ɔ́* in their base form—that is, that they displayed the regular paradigm of suffixed singulars—but that this suffix has been subsequently lost.[11] This hypothesis explains why the stem vowel in the base form is either short or overlong, but never long—the same levels of vowel length attested for suffixed singular base forms. In this analysis, the floating mora in the base form is interpreted as a diachronic reflex of the lost suffix.

2.5. SUMMARY. The floating mora is consistently present in two inflections, both within the paradigm of suffixless singular nouns: the demonstrative, and the pertensive with singular possessor. In the base form of suffixed singular nouns, the floating mora is restricted to a set of twenty-three nouns. This set presents the same quantity alternation as suffixed singular nouns, and on this basis the floating mora can be interpreted as an indication of morphological marking. In addition, the floating mora is found in the majority of plural nouns. We conclude that, on the basis of all the environments in which it is found, floating quantity can be interpreted as an instance of morphological marking, and therefore as an affix, rather than as part of the lexical specification of nominal roots.

In three of the four morphological forms in which it is found, the floating mora can dock on any following vocalic prefix. The pertensive with singular possessor stands out in this respect: here the floating mora can dock on the following vocalic prefix only if this vowel is specified for high tone and if its vowel quality is /a/. Importantly, the context in which the floating mora can dock is determined by the phonological characteristics, and not by lexical category or by morphosyntactic structure.

3. ACOUSTIC STUDY. In this section, we report on an acoustic study aimed at exploring the empirical basis for the hypothesized floating weight unit. This is worthwhile, because, as it stands, reports of floating moras have been solely based on qualitative evidence. A quantitative study therefore represents a worthwhile contribution to the evidence base.

3.1. METHODS. The target words we collected are shown in Table 3. This material is structured in terms of the orthogonal crossing of two factors. One is tone: ten of the nouns carry a low tone, and the other ten carry a high tone. The other is number: ten of the nouns are grammatically singular, and the other ten are grammatically plural. The presence of the floating mora is not determined directly by either of these factors by itself. Rather, our descriptive analysis postulates that the floating mora is part of the phonological representation of low-toned plural nouns (§2.1).

All of the target nouns are closed monosyllables with a short vowel. These specifications are fixed, so as to avoid confounds. The coda is invariably a sonorant coda, either a nasal or /l/. This class of consonants does not display allophonic variation in Shilluk, and they allow for easy segmentation of the boundary with the following vocalic prefix.

[11] The suffix *-ɔ* is realized weakly in Shilluk morphology in general, suggesting that it may be on a diachronic trajectory to being lost.

	SINGULAR		PLURAL	
LOW-TONED	kùl	‘warthog’	tùlᵘ	‘foreheads’
	ṭìm	‘forested area’	pèlᵘ	‘grinding stones’
	kàl	‘compound’	ɲìmᵘ	‘sesame’
	làŋ	‘cat’	lùlᵘ	‘steep river banks’
	twèl	‘section’	ṭòmᵘ	‘lyres’
HIGH-TONED	tɔ́ŋ	‘spear’	bjɛ́l	‘grain’
	tjél	‘elbow’	cíŋ	‘hands’
	wɔ́ŋ	‘grandmother’	rém	‘blood’
	líŋ	‘war’	ɲíŋ	‘eyes’
	gúl	‘joint’	jɛ́ṇ	‘trees’

TABLE 3. The target words.

These twenty nouns were recorded in two environments. They are illustrated in 22, both for a noun that has the floating mora, as in 22b,d, and for a noun that does not, as in 22a,c. One environment sees the target words followed by the verb *á-lîɪɪṭ-à*, as in 22a,b. According to the descriptive analysis in §2.1, the past-tense marker *á-* should display substantially greater duration when the preceding noun has a floating mora, as in the case of *tùl*ᵘ ‘foreheads’ in 22b, than following a segmentally comparable noun that does not, such as *kùl* ‘warthog’ in 22a.

(22) a. [kùl álîɪɪḍà]
kùl á-lîɪɪṭ-à
warthog PST-look-1SG
‘I looked at the warthog.’

b. [tùl ăalîɪɪḍà]
tùlᵘ à-lîɪɪṭ-à
forehead:PL PST-look-1SG
‘I looked at the foreheads.’

c. [gîn băa kùl]
gîn băa kùl
something:DEM NOMP warthog
‘This thing is a warthog.’

d. [gîk băa tùl]
gîk băa tùlᵘ
something.PL:DEM NOMP forehead:PL
‘These things are foreheads.’

The other environment, shown in 22c,d, has the target words embedded in utterance-final position. This utterance-final context serves to verify qualitatively that the target words do not have a vocalic suffix. In addition, it serves to ascertain the grammatical number of the noun, as this is cross-referenced on the subject noun, which is *gîn* if the target is singular and *gîk* if the target is plural.

The data were recorded from ten native speakers of Shilluk, five men and five women.[12] All had grown up in the Shilluk territory, near the city of Malakal. At the time of the recording, they all lived in Juba, the capital of South Sudan, which is outside of the Shilluk-speaking region. However, all lived with other speakers of Shilluk and used Shilluk on a daily basis.

The data were collected using the following procedure. The target words were elicited by explaining their meaning in Shilluk. Crucially, the target word was not offered to the

[12] The second author is one of the speakers.

participant as an example. Once the participant was aware of the target word, it was elicited in the above-mentioned frames: *gîn*/*gîk bǎa* X (utterance-final) and X *á-lîuɪ̯ṭ-à* (utterance-initial). The target word was first elicited and recorded once in the utterance-final context, and after that twice in the utterance-initial context. The order of presentation of items was randomized, and this order was reversed for half of the subjects.

In a small number of cases, the speakers uttered the utterance-final realization with a different subject, that is, *mə́n*/*mɔ́k* 'this one/these ones' instead of *gîn*/*gîk* 'this thing/these things'. This is not a problem, because *mə́n*/*mɔ́k* displays agreement for the grammatical number of the target noun, just as *gîn*/*gîk* does. The recordings were made using a headset-mounted microphone and a solid-state digital recorder. As there are twenty target words, we aimed to collect twenty utterance-final renditions per speaker, and forty utterance-initial ones. Over ten speakers, the expected total is 600 tokens, 400 in utterance-final context and 200 in utterance-medial context. This is indeed the number of items recorded; there were no missing values.

As noted above, the utterance-final renditions were used to ascertain (i) that the target word is a closed monosyllable, in other words, that the noun is not suffixed, and (ii) its grammatical number, on the basis of the agreement with *gîn*/*gîk*. In two cases—one item uttered by one speaker, and one uttered by another—there was a miscommunication, and the speakers produced a singular instead of an intended plural. The two utterance-initial renditions for each of these two items as uttered by these speakers were taken out of the data set, reducing the number of tokens from 400 to 396, and the number of items from 200 to 198. The data set is publicly available (Remijsen & Ayoker 2020). In the utterance-initial renditions, we segmented the duration of the prefix *á-* in *á-lîuɪ̯ṭ-à*. Below we present the results based on these measurements.

3.2. RESULTS. Figure 1 presents the descriptive statistics for the duration of the prefix *á-*, which is the constituent hypothesized to serve as a docking site for the floating mora at the right edge of the preceding noun. In the data set under investigation, the low-toned plurals are postulated to carry this floating mora (cf. Table 3). As seen from Fig. 1, the prefix *á-* has a substantially greater duration following low-toned plurals than following the three other groups of nouns. The mean values are 122 milliseconds (ms) following the nouns hypothesized to have floating quantity and 85 ms following the nouns hypothesized not to have floating quantity. The difference in the duration of the prefix when it is affected by the floating mora vs. when it is not, then, amounts to 37 ms, which is an increase of 43.5 percent, relative to the duration of the prefix when it is not marked by floating quantity.

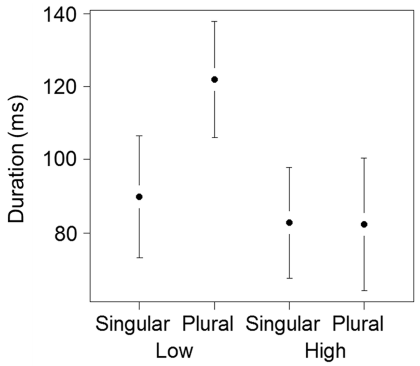


FIGURE 1. Means and standard deviations for the duration of the verb prefix *á-*, in milliseconds, by the grammatical number and specification for tone of the preceding noun. The low-toned plurals have a floating mora; the other factor levels do not (cf. Table 3).

As these are the raw duration values, the variability around the mean includes the influence of rate of speech. Even so, there is a substantial degree of separation: the whiskers encompass one standard deviation, which is 68 percent of the distribution. As seen from Fig. 1, these ranges do not overlap.

The effect of rate of speech can be seen clearly in Figure 2, which presents the durations of the prefix *á-* with and without the floating mora by speaker. Comparing speakers 1 and 5, for example, it is clear that speaker 1 displays longer durations than speaker 5, both with and without the floating mora. Notwithstanding the effect of speech rate, Fig. 2 also shows that, for each of the ten speakers, there is a difference in the predicted direction: the duration of the *á-* prefix is greater following the low-toned plurals, hypothesized to have a floating mora, than following the other nouns. The size of this difference ranges from 9 ms for speaker 10 to 58 ms for speaker 8. For two of speakers, specifically speakers 2 and 10, there is considerable overlap between the distributions. We do not have an explanation for why the difference is smaller for these two speakers.

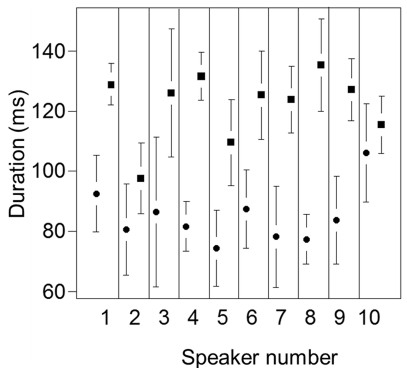


FIGURE 2. Means and standard deviations for the duration of the verb prefix *á-* (in ms), by speaker (marked by number) and by floating quantity (circles: no floating quantity; squares: floating quantity).

We used LINEAR DISCRIMINANT ANALYSIS to determine the degree of success with which the presence of the hypothesized floating mora can be predicted on the basis of the duration of the following *á-*. As it turns out, 90 percent of the items can be classified correctly for the presence or absence of the floating mora in this way.

Shilluk has a ternary vowel length contrast, and it is insightful to compare the effect of floating quantity on vowel duration with that of vowel length. Remijsen, Ayoker, & Jørgensen 2019 reports mean duration values of 68 ms for short vowels, 111 ms for long vowels, and 150 ms for overlong vowels. This means that, on average, short vs. long vowels are 43 ms apart, and long vs. overlong vowels 39 ms apart. The mean difference of 37 ms between prefix vowels with and without floating quantity is comparable to these values. Finally, the correct classification for vowel length on the basis of vowel duration was 96 percent (Remijsen, Ayoker, & Jørgensen 2019). This is somewhat higher than the correct classification result for the detection of the presence vs. absence of floating quantity.

3.3. SUMMARY. On average, the prefix *á-* is 43.5 percent longer following nouns postulated to carry a floating mora (122 ms) than following nouns without a floating mora (85 ms). All ten of the speakers display an effect in the expected direction, and for most of them the duration values in the two environments are well separated from one another, to the effect that most nouns can be classified successfully for the presence of a floating mora based on the duration of a following prefix vowel.

4. DISCUSSION AND CONCLUSION.

4.1. ALTERNATIVE INTERPRETATIONS. The phenomenon to be explained is the difference in the duration of vocalic prefixes between utterances like that in 23a and utterances like that in 23b. According to our analysis, words such as *tùl*$^{\mu}$ 'foreheads' in 23b have a floating weight unit at their right edge, and this unit of weight associates rightward across the word boundary, giving rise to increased duration of the prefix vowel. In contrast, words such as *kùl* 'warthog' in 23a do not condition an increase in the duration of the following prefix because they lack this floating weight unit.

(23) a. [kùl álîɪŋḍà]
kùl á-lîɪŋṭ-à
warthog PST-look-1SG
'I looked at the warthog.'

b. [tùl ăalîɪŋḍà]
tùl$^{\mu}$ á-lîɪŋṭ-à
forehead:PL PST-look-1SG
'I looked at the foreheads.'

The logical alternative is that the greater duration found on the following prefix in 23b actually represents morphological marking on the verb. This alternative analysis is represented in 24. Note that, in the gloss, the plural nature of 'foreheads' is not morphologically marked at all on the noun itself. Instead, the past-tense-marking verb prefix combines with a nonconcatenative marker for number agreement with the preceding argument.

(24) [tùl ăalîɪŋḍà]
tùl áa-lîɪŋṭ-à (transcription and gloss under competing analysis)
foreheads PST:PL.AGR-look-1SG
'I looked at the foreheads.'

The attraction of this analysis is that we do not need to postulate the typologically exceptional phenomenon of a floating weight unit that crosses a word boundary. In the case of plural nouns, this analysis is conceivable: over three quarters of suffixless plurals actually condition increased duration on following vocalic prefixes. However, there is a lot of evidence against this analysis. For example, it leaves unexplained why a word beginning with a vocalic prefix would display this kind of number agreement following some plural nouns but not others, as shown in 12 above. Singulars offer comparable counterevidence against this alternative analysis. This is illustrated in 25: 'mountain' and 'wild cat' are both singular nouns; here again, the difference in the duration of the prefix of the following noun—which the reader can observe in the associated sound files—cannot be interpreted as agreement marking.

(25) a. [kĭt áalîɪŋḍà]
kĭt$^{\mu}$ á-lîɪŋṭ-à
mountain PST-look-1SG
'I looked at the mountain.'

b. [gwăŋ álîɪŋḍà]
gwăŋ á-lîɪŋṭ-à
wild.cat PST-look-1SG
'I looked at the wild cat.'

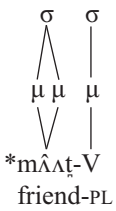
While this alternative analysis does not offer an adequate account of the Shilluk phenomenon, it is of comparative interest. In closely related Dinka, finite verb forms carry

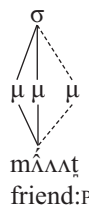
a prefix in declarative clauses, and this prefix is marked for the number of the preceding topic: it is *ă-* if the preceding topic is singular, and *ăa-* if it is plural (cf. Andersen 1991:271–72). This phenomenon is illustrated in 26 on the basis of our data from the Rek dialect of Dinka. Note that in 26a the prefix indexes the singular number of the preverbal topic, and in 26b the plural number of a plural topic. We speculate that this kind of number agreement can readily evolve out of a situation like the Shilluk one, in which the majority of suffixless plural nouns have floating quantity and the majority of suffixless singular nouns do not.

(26) Dinka
  a. ràaan ă-lèl
     person DECL-isolate:2SG
     'You are isolating someone.'
  b. rn̰oor ăa-lèl
     people DECL:PL.AGR-isolate:2SG
     'You are isolating people.'

Another alternative analysis that does not involve the association of a weight unit across a word boundary does not make reference to floating quantity at all. Instead, the short and long versions of any prefix vowel that presents the quantity alternation can be interpreted as allomorphs (cf. Bermúdez-Otero 2018), with the choice determined by a specification in the lexical representation of the preceding noun. This kind of analysis is postulated for French liaison in Tseng 2003. Hence, the word 'mountain' would have a feature specifying that it combines with the long-version allomorph of the past-tense prefix. In this analysis, there is no need to postulate a floating mora. This analysis is less attractive than the one proposed in §2 in that it fails to explain why the tone pattern of the long allomorph is directly determined by the end target of the specification for tone of the preceding word. Consider that, in 23b, the prefix carries a rising pitch [ăalîɪŋn̰à], whereas in 25a, which equally involves the long form, the prefix has high pitch [áalîɪŋn̰à]. If the phenomena are analyzed in terms of a floating mora that is part of the preceding word to begin with, then this difference in tonal specification is readily accounted for: [ăalîɪŋn̰à] in 23b has rising pitch, that is, a low-to-high contour, because the preceding word *tùl*$^{\mu}$ carries a low tone, which carries across to the prefix as the floating mora docks. In contrast, [áalîɪŋn̰à] in 25a has high pitch because the rising tone on the preceding word *kǐt*$^{\mu}$ ends in a high target, which again carries across to the prefix as the floating mora docks. In this way, the melody of the prefix vowel is predictable under the floating mora analysis, whereas it needs to be circumscribed separately in the allomorphy analysis.

4.2. FLOATING MORA AND DIACHRONIC CHANGE. The phenomenon of the floating mora in Shilluk is insightful in relation to the analysis of compensatory lengthening as a diachronic process, as put forward in Hayes 1989. Consider the singular–plural pair *mâʌn̰–mâʌʌn̰*$^{\mu}$ 'friend:SG–PL'. Following Andersen 1990, and in line with Hayes 1989, we hypothesize that overlength in Shilluk developed diachronically from stems with a long vowel that carried a suffix, that is, CVVC-V → CVVVC. On this assumption, the stage that preceded this process can be represented as in 27a. Following the analysis of compensatory lengthening in Hayes 1989, the development of an overlong vowel following the loss of the suffix can be represented schematically as in 27b. The current state, however, is 27c. That is, the quantity of the lost suffix makes its appearance twice in the synchronic phonological representation: as overlength, and as a floating mora.

(27) a. 

b. 

c. 

This suggests that historically, the vocalic suffix illustrated schematically in 27a was in hiatus with following vocalic prefixes, and induced greater duration in the latter.[13] When compensatory lengthening applied, this durational effect was retained, now without association to segmental content.

Interestingly, there are other parts of the grammar where the effects of compensatory lengthening are manifested in overlength, but without the accompanying floating mora. In the morphological paradigms of transitive verbs, for example, vowel length alternations are very common. Consider *á-lɛ̄ɛɛŋ*, the past-tense applicative voice form of *lɛ̀ɛŋ* 'throw' (Remijsen & Ayoker 2018). Such differences in vowel length between verb forms can be attributed to the effects of compensatory lengthening in conjunction with the loss of vocalic suffixes (cf. Andersen 1990). To the best of our knowledge, however, verbs never carry floating quantity.

And whereas the floating mora in *mʌ́ʌʌt̰*μ 'friends' can be related to a suffix at an earlier diachronic stage, there are other plurals where this is not the case. Consider the comparative evidence on the singular–plural pair 'egg(s)' in Table 4. Following Andersen's interpretation of Päri as the conservative daughter language, we hypothesize that, in the common ancestor, the singular was suffixed, and the plural was historically suffixless. In this context, the floating mora in the Shilluk plural is puzzling, as there never was a suffix to begin with. We hypothesize that the floating mora here is the result of analogical extension: as noted in §2.4, all but twelve suffixless plurals that carry a tone other than mid or high have floating quantity in Shilluk.

	SINGULAR 'egg'	PLURAL 'eggs'
Päri	tɔ̀ŋ-ɔ́	tɔ̀ŋ
Dinka	twɔ̌ɔŋ	tóŋ
Shilluk	tɔ̂ŋ-ɔ̀	tɔ̂ŋμ

TABLE 4. Singulars and plurals for 'egg' in Shilluk and two other West Nilotic languages. The Päri singular comes from Andersen 1990:17 and the corresponding plural from Andersen, p.c.

These considerations indicate that the floating mora cannot be attributed in a straightforward manner to vocalic suffixes at an earlier stage of the language. A lost suffix may be reflected both in overlength and in a floating mora (*mʌ́ʌʌt̰*μ 'friend:PL'); alternatively, a lost suffix may be reflected in overlength without floating quantity, as in Shilluk verb morphology (e.g. *á-lɛ̄ɛɛŋ* 'PST-throw:APPL'); and finally, there is evidence that the floating mora is found in forms that never had a vocalic suffix in the first place (e.g. *tɔ̂ŋ*μ 'egg:PL').

4.3. CONCLUSION. On the basis of qualitative and quantitative evidence, we conclude that a weight unit that is not associated with the segmental sequence associates across a word boundary in Shilluk. We have interpreted this weight unit as part of the morpho-

[13] Synchronically, vocalic suffixes may elide before prefix vowels, with the latter displaying increased duration (Remijsen, Miller-Naudé, & Gilley 2015:595–96).

logical exponence of plural number, pertensive with singular possessor, demonstrative, and singulative. Alternative analyses that do not involve a floating weight unit crossing a word boundary are inadequate in an explanatory sense.

Our findings suggest that the typological range of morphological quantity is wider than previously assumed, for example in Zimmermann 2017, and that the formalism to represent morphological operations involving quantity will need to be revised to include associations across a word boundary. As a direction for further research, we recommend the study of floating quantity in related languages.

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